BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 07062

SUBJECT: Effects of In-Orbit Servicing on Nimbus Configuration - Case 105-3

DATE: July 18, 1969

FROM: A. S. Kiersarsky

ABSTRACT

Nimbus was selected as a candidate satellite to determine how a satellite may be affected by an on-orbit servicing requirement. Emphasis was directed to accessibility characteristics to assess their impact on satellite configurations. A Space Station hangar facility was examined to better understand hangar size and satellite handling requirements. Alternately, the satellite design was reconfigured by: (1) partially expanding the basic design, and (2) a reconfigured design, to determine how, if at all, accessibility may be improved.

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MEMORANDUM FOR FILE

INTRODUCTION

The Nimbus was selected as representative of a class of complex R&D satellites for potential satellite servicing in orbit. The intent of this study was to examine configurational aspects of the Nimbus satellite to assess the impact on design and the effect on orbital facilities.

The Nimbus, Figure 1, like many satellites, was designed using a modular approach with equipment mounted in separate bays and with removable panels to assist in system orientation and installation. It was not configured for orbital servicing, and since it had to meet launch vehicle weight and shroud envelope constraints, Nimbus was designed as compact and dense as the structural and thermal environment would permit. This design approach provides only the minimum degree of accessibility necessary for factory fabrication, testing, and adjustment.

Since the available design data for this study was quite general, the depth of this study is somewhat limited. The configurations presented are intended to provide "strawman" concepts to stimulate additional thought and assist in the formulation of more detailed study tasks. Several areas of interest were examined, namely a hangar servicing facility for the current Nimbus, an expanded version of the Nimbus, and an alternate design approach. The latter configurations would be serviceable in situ or from a hangar.

HANGAR FACILITIES

Satellite servicing could be conducted in a hangar facility which is part of a service tug or a space station. Such a facility will provide not only a shirt-sleeve environment, but also the capability of more extensive supporting systems. One possible configuration is shown in Figure 2 (enveloping the current Nimbus).

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(NASA-CR-106547) EFFECTS OF IN-ORBIT SERVICING ON NIMBUS CONFIGURATION (Bellcomm, Inc.) 12 p

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Transport of the satellite to the hangar is not part of this discussion but a means of transport will be required to place the satellite in close proximity to the hangar. As shown in Figure 2 the hangar compartment, when open to the space environment, is configured with a remote arresting system supported from an extendable monorail system. Having arrested the satellite it is then retracted within the hangar. The hangar door is secured, and the hangar is pressurized to permit shirt-sleeve access. The hangar was sized to accept the Nimbus in solar panel deployed condition. The hangar envelope shown closely approximates the vacuum facility used during the operational test and checkout phase of fabrication. The hangar is configured with an adjustable satellite supporting structure (to permit service of other satellites also) as well as a maintenance and servicing volume which may consist of optical benches, checkout equipment, etc. For comparison, the envelope of a 22 ft dia hangar is shown.

EXPANDED NIMBUS

The effect of increasing the volumetric size of the Nimbus was examined. The areas of primary interest were the sensor ring and the attitude control system housing, both of which are enclosed areas with densely packaged equipment. No assessment was made of the sensor equipment mounting since this equipment is located in free space on the lower outer face of the sensor ring and appears to be accessible for servicing or replacement.

The sensor ring is a multi-sided polygonal torus structure composed of modular bays and a space frame structure internal to the torus. Both the bays and internal frame are presently used for equipment* support. One of the principal constraints for access to the sensor ring is the location and routing of wire harnesses which essentially cover the upper surface of the sensor ring. These harnesses are in turn covered by an insulation blanket.

To provide increased accessibility, the outer diameter was increased along with the height of the sensor ring (which retains the basic geometric design characteristics). This change of size increased the volumetric content by a factor of three. As shown in Figure 3 one compartment was examined to determine what features should be employed to assist the servicing function. Some of the factors considered are noted. Also the application of a manipulator or an astronaut is illustrated.

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*This equipment includes power supplies, sensor electronics, telemetry and data handling, command systems, etc.

The attitude control system housing (ACS) is a modified hexagonal shaped compartment within which are supported the ACS system, the solar array drive and support system, and other electronics. Here again the design of this compartment satisfies the factory fabrication requirements but easy access requires some modification.

The basic hexagonal shape was retained but enlarged by a factor of two, as shown in Figure 4. Several changes were made to this unit, one of which was relocation of the solar array drive systems as a separate assembly permitting more accessibility. Of the remaining units, all electronic or "black box" equipment is located on hinged panels within the upper part of the compartment. Control mechanisms, flywheels, and the ACS gas supply are located in the lower part of this compartment. Access panels in this area provide access not only to this equipment but also to wire harness connectors for equipment located in the upper part of the compartment. Some of the features are noted in Figure 4.

A comparison of the present satellite configuration with the expanded version (Figure 5) reflects a general expansion while retaining the basic geometric characteristics of the satellite.

As a result of this expansion of Nimbus, there is a volumetric and weight increase, but this appears to be one of the penalties that will be associated with ready accessibility for servicing.

RECONFIGURED DESIGN FOR SERVICEABILITY

In addition to expansion of the present Nimbus configuration, an alternate approach was studied to explore the possibilities of greater accessibility. This design (figure 6) is configured with a separate sensor systems unit composed of the sensors and their supporting electronics, and a support systems unit composed of the various supporting or housekeeping systems.

For this configuration, the solar array power source was replaced by RTG units. This essentially provided a basis for extensive reconfiguration since paddle orientation and rotation clearance no longer was a design factor.

The sensor unit is a polygonal sided torus structure to which the different sensors are mounted, (same as on Nimbus) with only the sensor electronics mounted within the compartmented torus.

All of the supporting systems equipment are mounted in the support systems unit which is a cylindrically shaped compartmented assembly. As shown in Figure 6, these systems have been located as separate entities.

Accessibility to the sensor unit is provided in essentially the same fashion as in the expanded Nimbus (i.e. access panels). But access to the support unit subsystems is through only two access panels on either side of this unit. The support unit, cylindrically shaped with a center beam from top to bottom, provides sufficient volumetric content for maximum accessibility to service and replace equipment. It is noted that the total length of this configuration is approximately the same as the current Nimbus.

CONCLUSIONS

After having reviewed the two enclosed areas of the Nimbus satellite the following are some factors which appear to be significant to the serviceability of satellites. Some of these are inherent to the basic design.

- Equipment should be configured to modular type containers.
- Decrease in volume utilization (i.e., low density packaging) appears to be unavoidable.
- Access panels either hinged or readily removable are required.
- All fasteners should be captive type.
- Areas of access should be free of cabling and harnesses.
- Cabling and harnesses should be routed in areas where no disassembly is required.
- Connectors should be readily accessible through equipment access doors.
- Insulation should be segmented and fixed to access panels.
- Replacement of solar panels with RTG's can simplify the configuration of the Nimbus for servicing purposes.

These are just some of the factors, from a configuration point of view, which would allow servicing in an easier manner.

A. S. Kiersarsky

1013-ASK-dmu A. S. Kiersarsky

Attachments

Copy to
See last page

REFERENCE

1. General Electric, Space Systems Organization, "Nimbus III, Reference Manual," April, 1969.

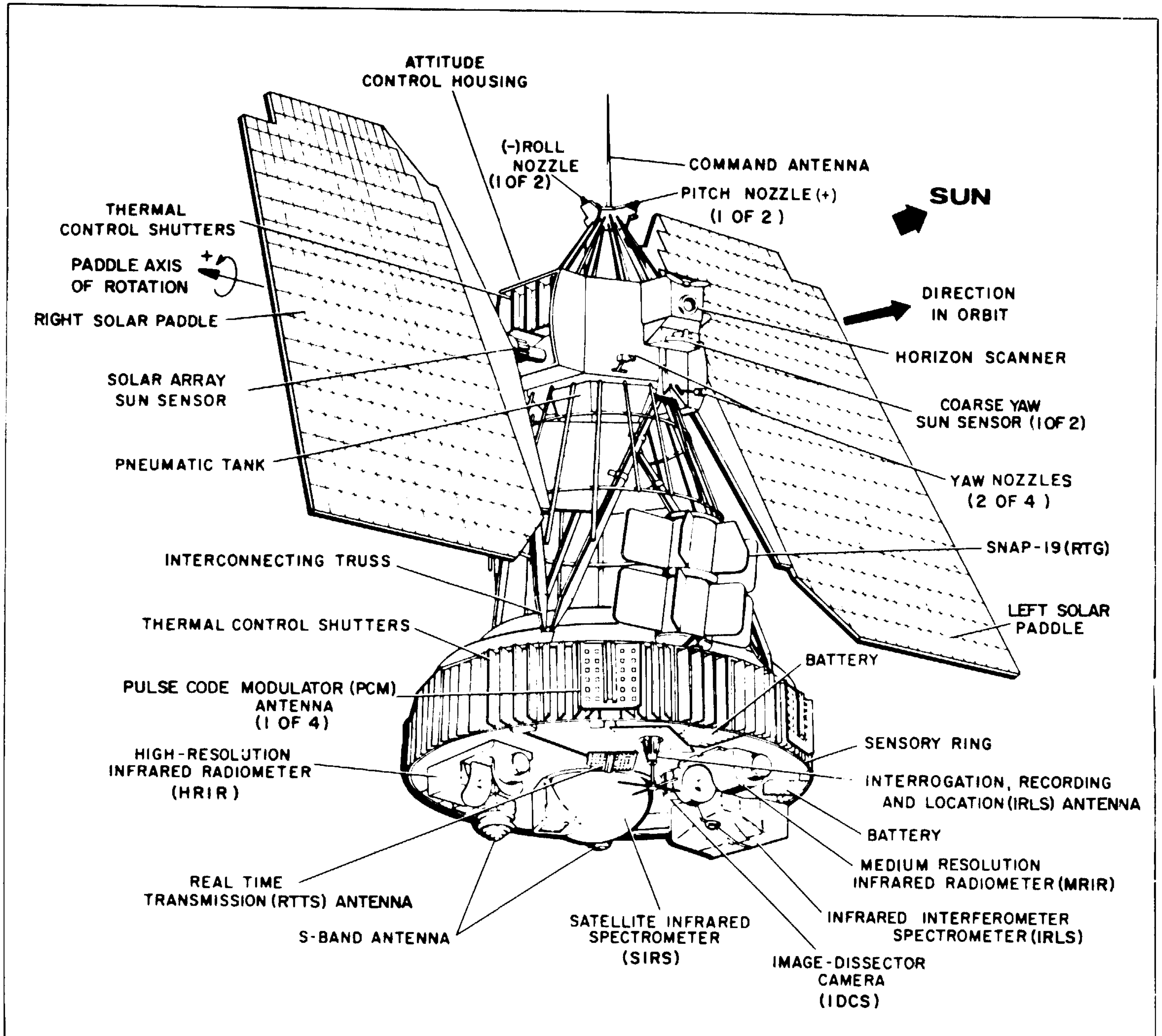
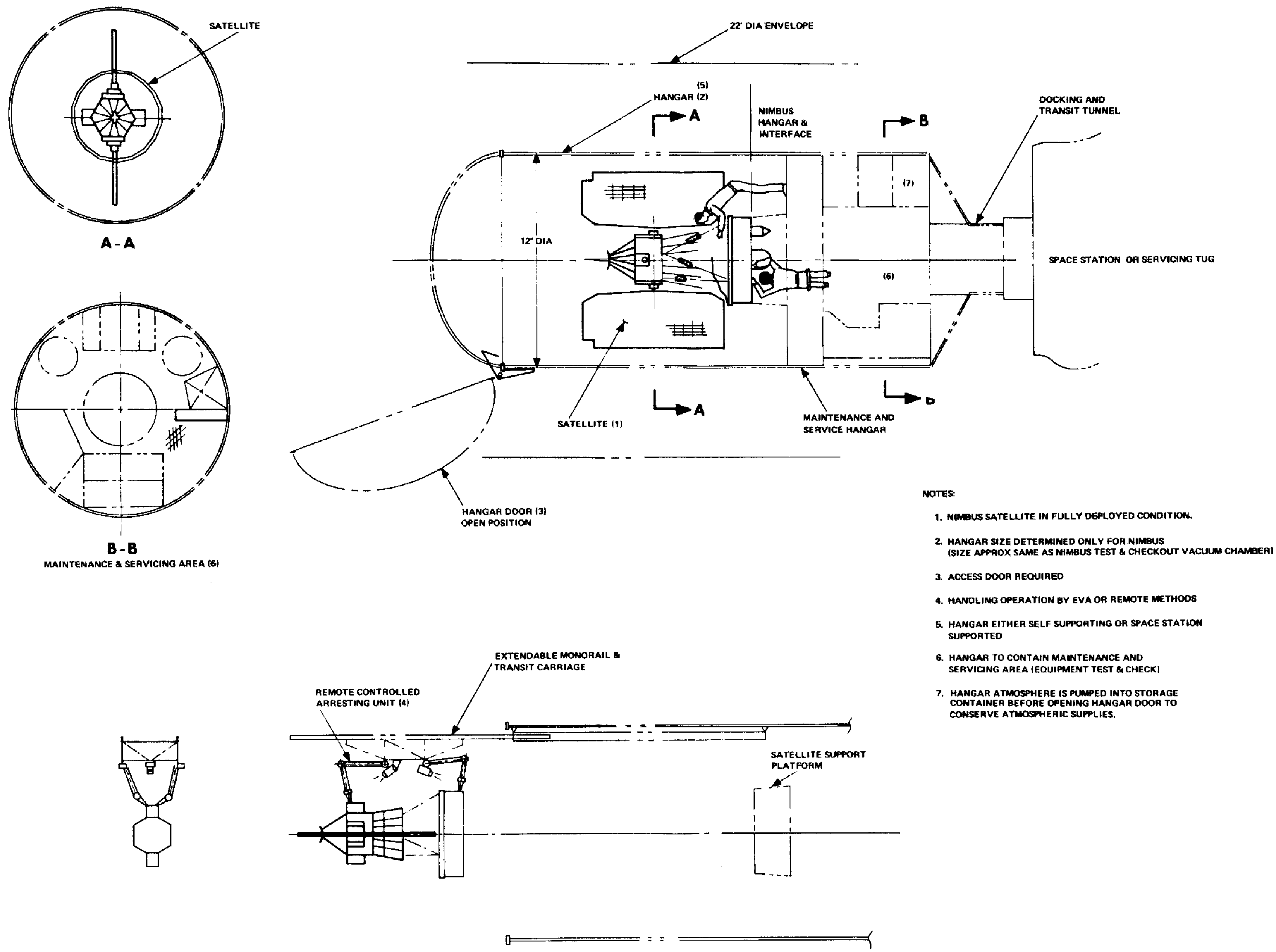


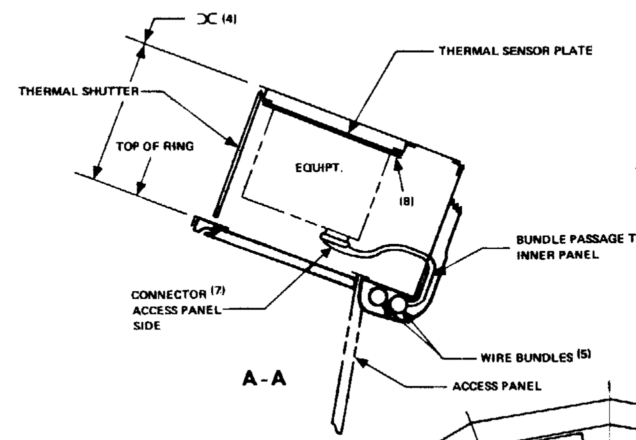
FIGURE 1 - NIMBUS III SPACECRAFT CONFIGURATION

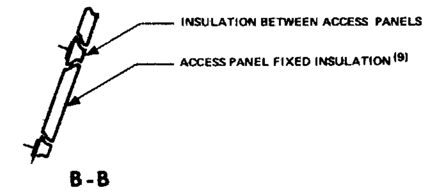


NOTES:

1. NIMBUS SATELLITE IN FULLY DEPLOYED CONDITION.
2. HANGAR SIZE DETERMINED ONLY FOR NIMBUS (SIZE APPROX SAME AS NIMBUS TEST & CHECKOUT VACUUM CHAMBER)
3. ACCESS DOOR REQUIRED
4. HANDLING OPERATION BY EVA OR REMOTE METHODS
5. HANGAR EITHER SELF SUPPORTING OR SPACE STATION SUPPORTED
6. HANGAR TO CONTAIN MAINTENANCE AND SERVICING AREA (EQUIPMENT TEST & CHECK)
7. HANGAR ATMOSPHERE IS PUMPED INTO STORAGE CONTAINER BEFORE OPENING HANGAR DOOR TO CONSERVE ATMOSPHERIC SUPPLIES.

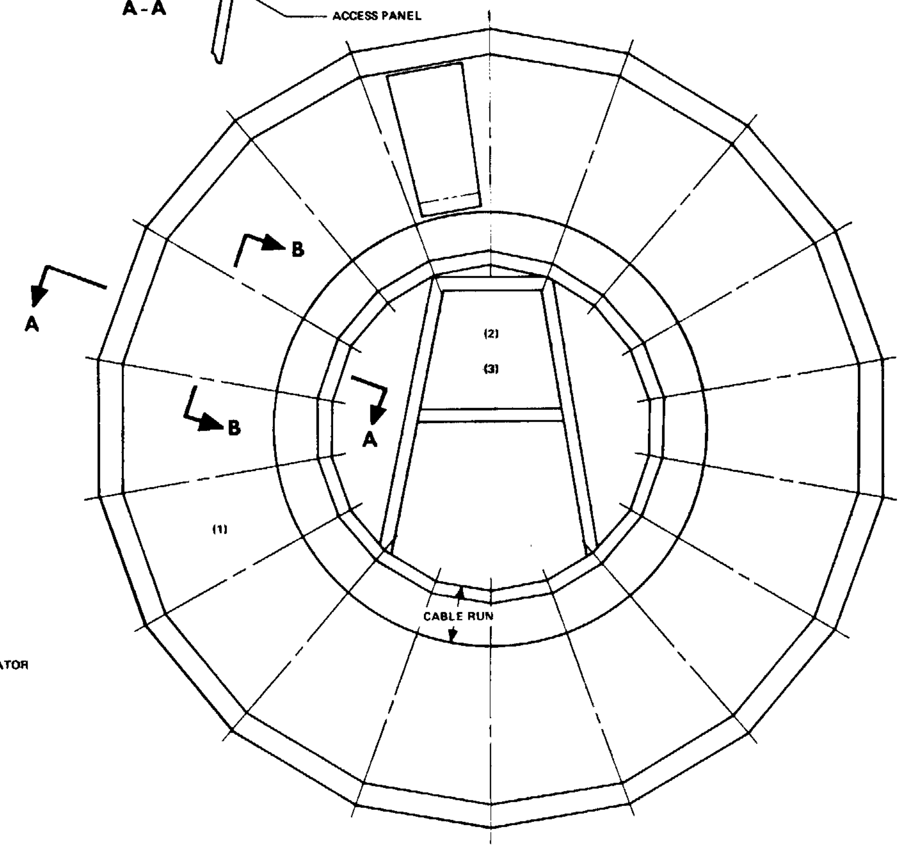
FIGURE 2 NIMBUS SATELLITE HANGAR SUPPORT

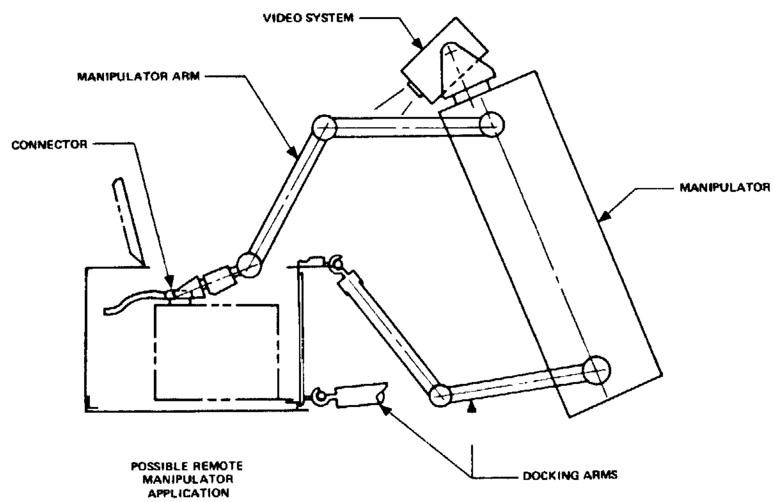




NOTES:

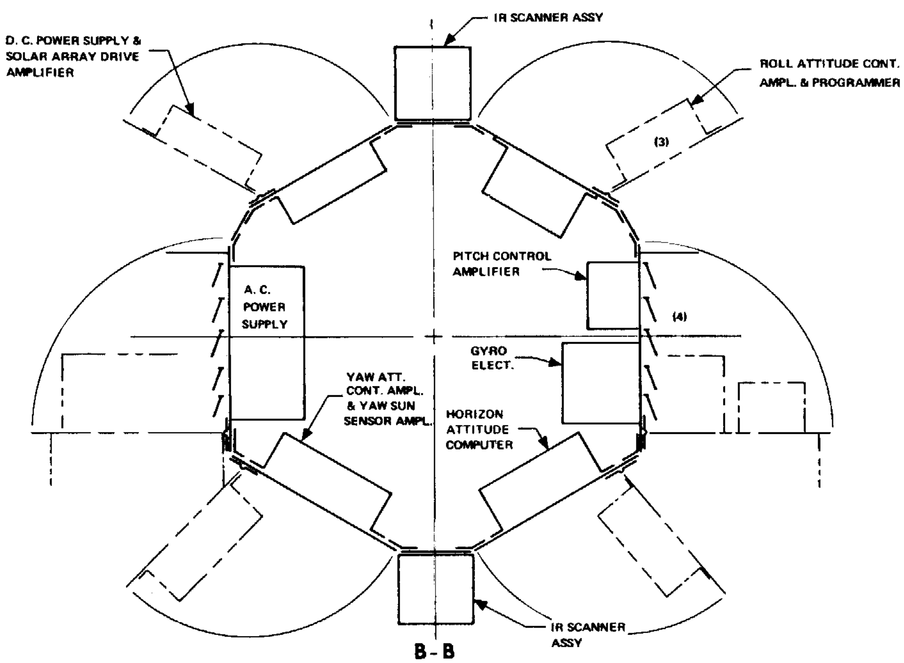
1. SENSOR RING INCREASED IN DIAMETER. RING-VOLUME INCREASES FROM $11FT^3$ TO $31FT^3$
2. ALL EQUIPT. PRESENTLY LOCATED WITHIN SPACE FRAME INTERIOR TO SENSOR RING TO BE RELOCATED IN SENSOR RING (EXCEPT EXPTS).
3. SIZE OF SPACE FRAME AREA KEPT THE SAME AS PRESENT
4. DEPTH OF SENSOR RING INCREASED TO PROVIDE SUFFICIENT VOLUME FOR ACCESSIBILITY
5. CABLING TO BE ROUTED ALONG FIXED AREA
6. HARNESSES TO EQUIP. ROUTED ALONG INSIDE CIRCUMFERENCE TO PROVIDE ACCESS FROM INSIDE FACE OF SENSOR RING
7. ALL CONNECTORS LOCATED ON ACCESS PANEL SIDE OF EQUIPT. FOR ACCESSIBILITY & READY DISCONNECT
8. EQUIPT. ATTACH FASTENERS, CAPITIVE TO UNIT, ARE ACCESSIBLE FROM PANEL SIDE
9. INSULATION REVISED TO PROVIDE FIXED INSULATION ON ACCESS PANELS OVERLAPPING ADJOINING INSULATION
10. ACCESS TO SHUTTER SYSTEM THROUGH EQUIPT. ACCESS PANELS





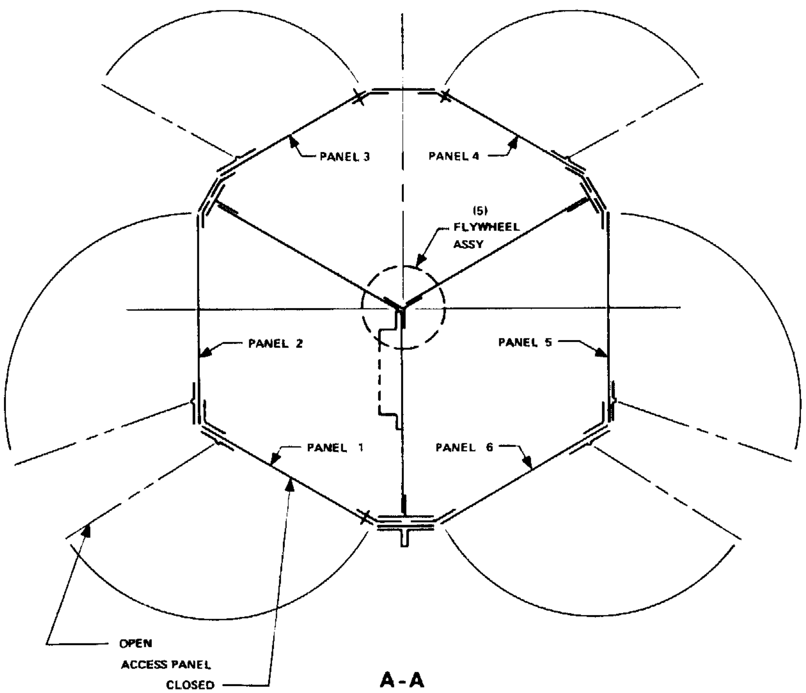
POSSIBLE REMOTE
MANIPULATOR
APPLICATION

FIGURE 3 NIMBUS SENSOR RING CONFIGURED FOR SERVICING & MAINTENANCE OF EQUIPMENT.



B - B

EQUIPMENT ACCESS ARRANGEMENT
UPPER BAY

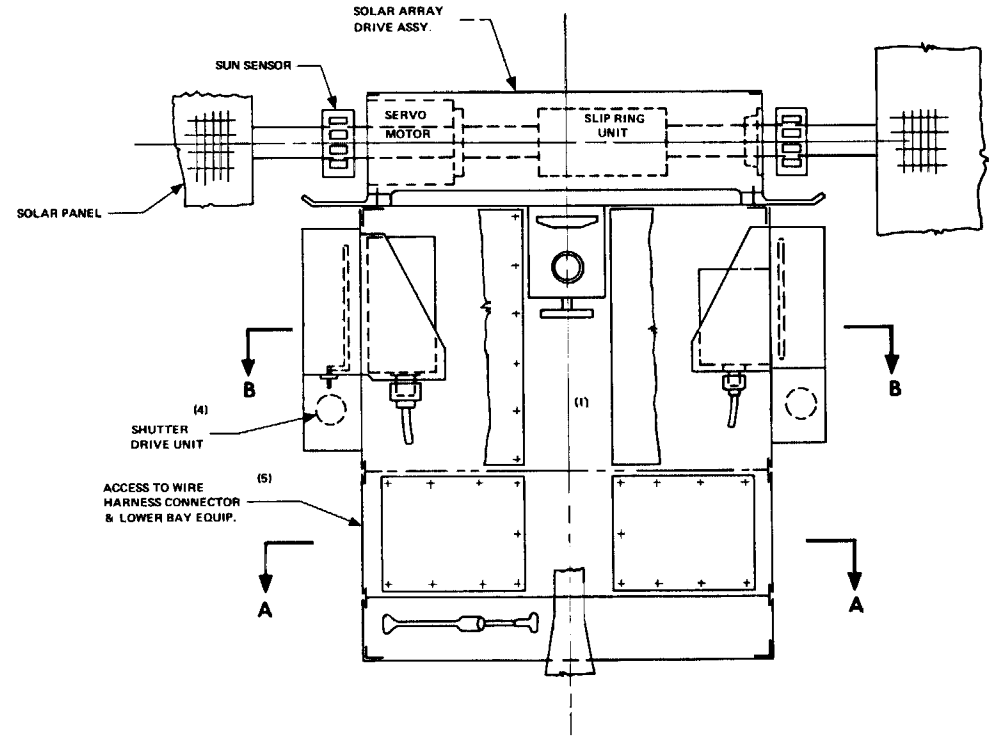


A - A

ACCESS PANEL ARRANGEMENT
LOWER BAY

NOTES:

1. ACS HOUSING INCREASED IN VOLUMETRIC CONTENT BY A FACTOR OF 2
2. RELOCATED SOLAR ARRAY DRIVE (SAD) AS A SEPARATELY CONTAINED ASSEMBLY TO TOP OF ACS HOUSING
3. ELECTRONIC EQUIPMENT (BLACK BOXES) MOUNTED TO ACCESS PANELS
4. EQUIPMENT REQUIRING ACTIVE THERMAL CONTROL INTEGRATED INTO ACCESS PANEL BY LOCATING BOTH THE THERMAL SHUTTERS AND DRIVE MECHANISM ON PANEL
5. ACCESSIBILITY PANELS FOR WIRE HARNESS CONNECTOR ACCESS
   NOTE: CONNECTORS ARE LOCATED ON SIDE OF EQUIPMENT NEAREST TO ACCESS AREA. THIS ELIMINATES HARNESS LOOPING.
6. FINE ATTITUDE CONTROL UNITS PLACED IN LOWER PART OF COMPARTMENT. (ACCESS THRU LOWER PANEL)

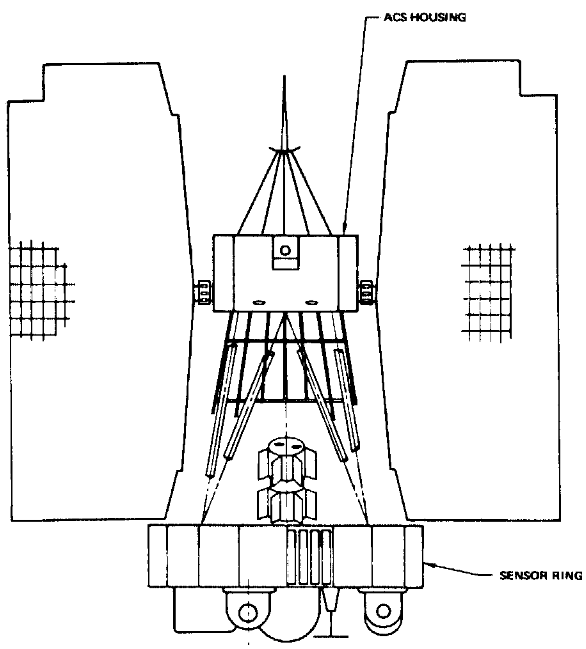


VIEW LOOKING ALONG PITCH
AXIS ACS HOUSING

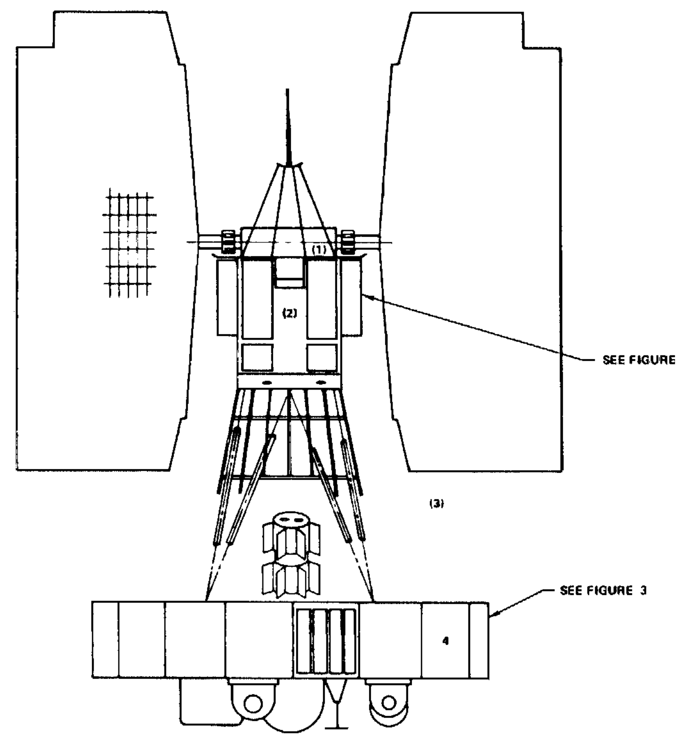
FIGURE 4-

NOTES

1. SOLAR ARRAY DRIVE AND PANELS RELOCATED
2. ACS HOUSING INCREASED IN SIZE (LENGTH ONLY)
3. TRUSS STRUCTURE RECONFIGURED
4. SENSOR RING INCREASED IN SIZE (LENGTH & DIAMETER)
5. EXPANDED VERSION APPROX. 20% LONGER
6. BASIC DIAMETER INCREASED APPROX 40%



NIMBUS III AS PRESENTLY CONFIGURED



NIMBUS III EXPANDED (5) (6) CONFIGURATION

FIGURE 5-

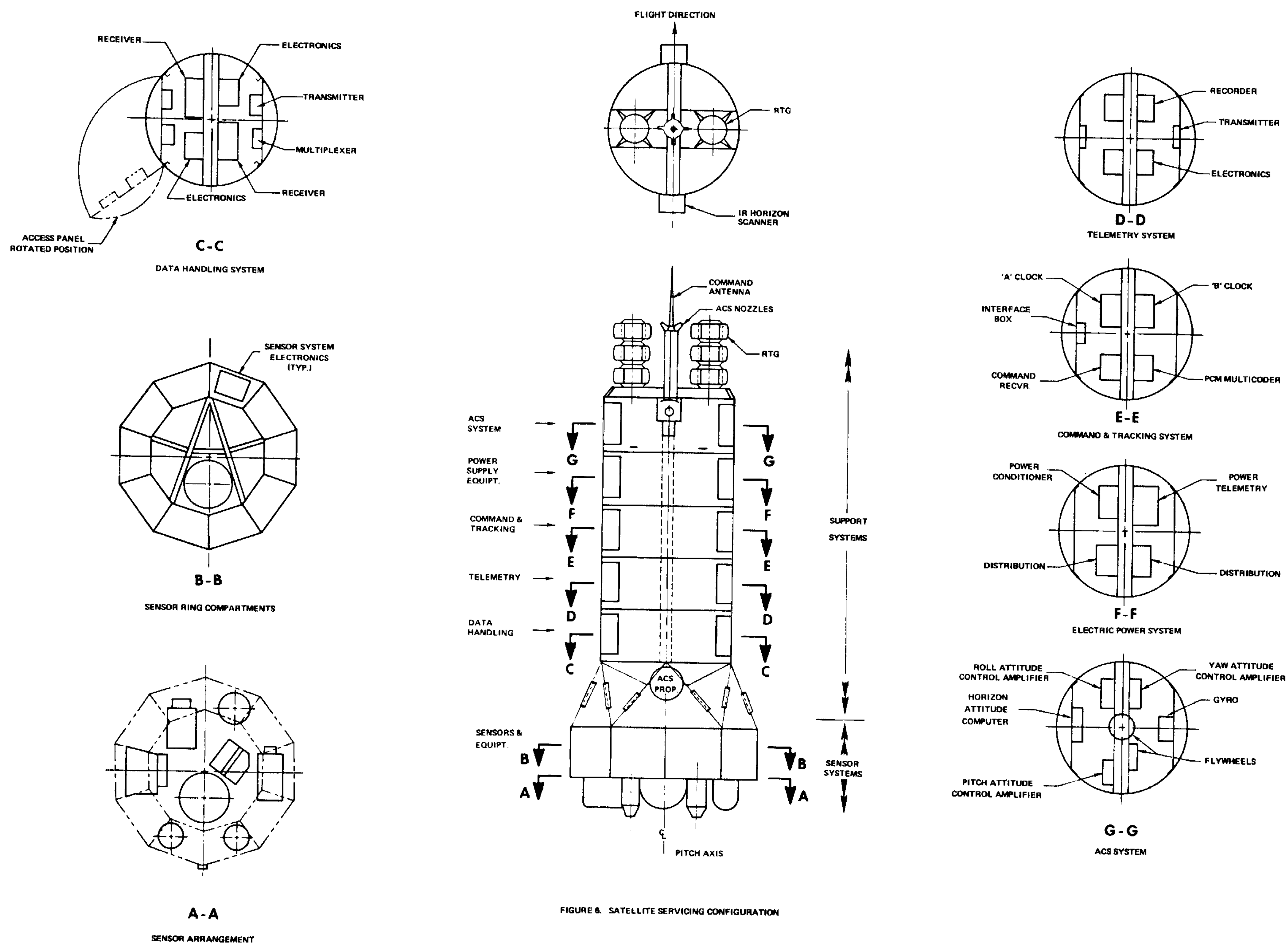


FIGURE 6. SATELLITE SERVICING CONFIGURATION

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